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Weir management as a tool for mitigating the effects of invasive freshwater mussels in impounded river sections

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Introduction

The biodiversity in the distributaries of the River Rhine has strongly decreased due to river regulation and environmental deterioration (Bij de Vaate et al., 2006). In spite of ecological rehabilitation programmes, riverine biodiversity has only partly recovered. Within impounded river sections the aquatic invertebrate communities are still impoverished and strongly dominated by non-native invasive species such as Asiatic clams (*Corbicula fluminea*), Zebra mussels (*Dreissena polymorpha*) and Quagga mussels (*Dreissena rostriformis bugensis*) (Leuven et al., 2009). Werner and Rothhaupt (2008) hypothesized that a fast drop in water level during harsh winter conditions could be used as a management tool to control invasive, non-native mussels. During the severe winter of 2012, an unintended large scale experiment unfolded in the River Nederrijn and offered opportunities to validate this hypothesis. On 8 February 2012, three weirs in the River Nederrijn were opened to prevent damage to hydraulic infrastructure by drifting ice. This caused a sudden decrease in water level of the River Nederrijn (Fig. 1). The water level in this river and connected water bodies decreased from 0.5 to up to 3.4 m and low water conditions lasted for at least seven days. Data from our regular fauna survey in the rivers Nederrijn and Meuse allowed us to assess the effects of this extremely low-water event during severe winter conditions on invasive freshwater mussels on hard substrates.

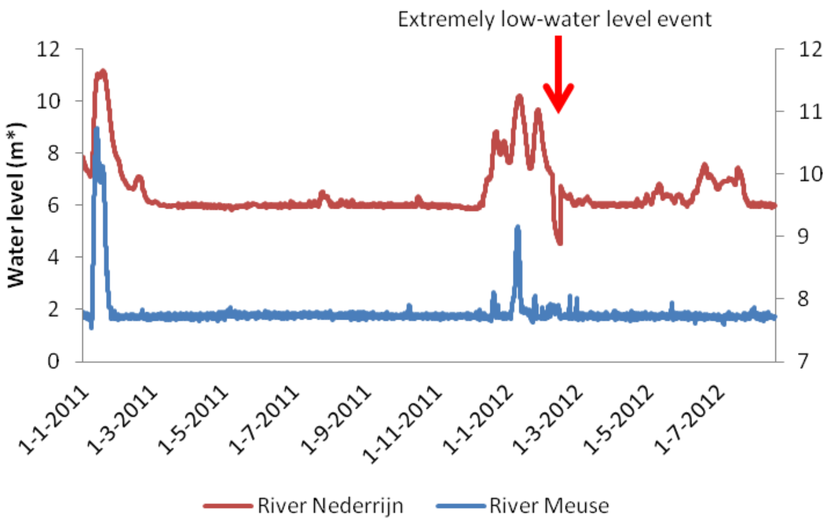

*Figure 1: Water levels of the Rivers Nederrijn (left axis) and River Meuse (right axis) during the period January 2011-August 2012 at gauging stations at Driel and Mook, respectively. * above average sea level.*

Material and methods

The density and size distribution of mussels on groyne stones in the impounded sections of the River Nederrijn at Lexkesveer (extreme event) and the River Meuse at Mook (reference site) were determined. At each location mussels were collected from five stones that were sampled 30 to 60 cm below the average low water level. The surface area of each stone was measured. In the laboratory the mussels were identified and counted. Subsequently their length was measured. Mussels were sampled one time before (t=0) and two times after (t=1 and 2) the extremely low-water event. Five standardized samples of dead, washed up molluscs at the river banks near Lexkesveer were taken directly after the extremely low-water event and 6 months later in order to estimate their mortality. The differences between length frequency distributions were tested with ANOVA and a Games-Howell post-hoc test. A paired student t-test was used to assess the statistical difference in the number of individuals washed up. Species density was tested with a two way ANOVA. The variances were not equal and therefore a non-parametric two way ANOVA was performed according to the Schreirer-Ray-Hare test. A Mann Whitney U test was then used to assess at which sampling dates densities differed. All statistical tests were performed using SPSS 19.0.

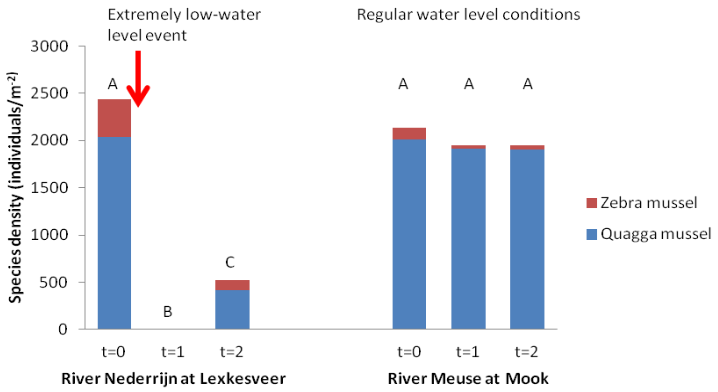

Figure 2: Mussel densities before (t=0), directly after (t=1) and six months after (t=2) the low-water event in the River Nederrijn at Lexkesveer and at the reference site in the River Meuse at Mook. The mussel density at Lexkesveer directly and six months after the extreme event was significantly lower than before (P=0.008). The density after the event was also significantly lower than in the River Meuse (P=0.008).

Results and discussion

The results clearly show that the overall density of Zebra and Quagga mussels was negatively affected by the extremely low-water event in the River Nederrijn (Fig. 2), at t=1 the majority was detached or were found dead. No change in density of mussels was recorded in the River Meuse. The slight increase in density in the River Nederrijn six months after the event indicates that re-colonisation occurs (Fig. 2).

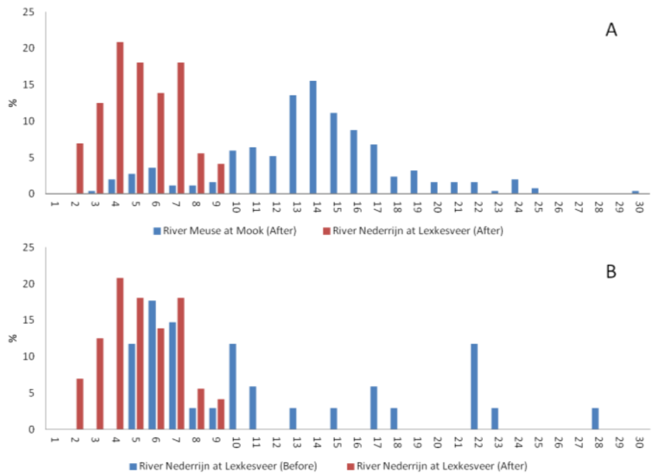

Figure 3: A: The proportion of Quagga mussel individuals per size class for the River Nederrijn was significantly smaller than for the River Meuse (P<0.001). B: Proportion of Quagga mussel individuals per size class before and after the event in the River Nederrijn differed significantly (P<0.001).

However, this density is still almost five times lower than before the event. Therefore, it is expected that full recovery of the mussel population will take several years. This is supported by the significantly smaller size of Quagga mussels found six months after the event in the River Nederrijn opposed to that of specimens collected in the River Meuse (Fig. 3). The population in the River Meuse consisted of at least three year cohorts with a size ranging 3 - 30 mm, whereas the population in the River Nederrijn after six months was composed of only one 0+ cohort with a size ranging 2 - 9 mm. The significantly larger number of mussels washed up on the banks directly after the event indicates that the effect of the extremely low-water event also affected other molluscs including species living in and on sediments (Fig. 4). However, 99.4% of the individuals washed up sampled directly after the event consisted of non-native species.

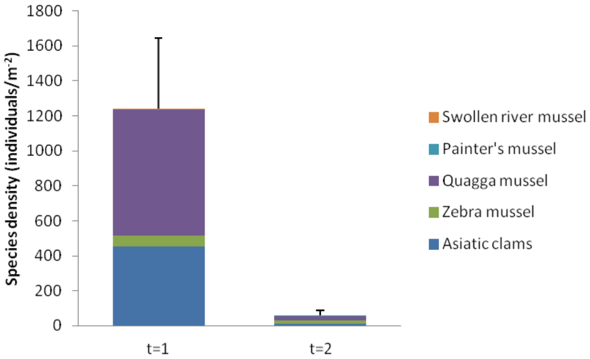

Figure 4: Composition of washed up species from the River Nederrijn at Lexkesveer directly after the event and six months later. The density of individuals washed up directly after the event was significantly larger than that six months later (P=0.015).

Conclusions

- Creating extremely low water conditions by weir management during severe winters appears to be an effective tool for controlling population densities of non-native invasive freshwater mussels in impounded river sections.
- The full recovery of invasive mussel populations after an extreme mortality event will take several years.
- The assessment of long term effects of weir management on native as well as non-native species composition and diversity is recommended.

Acknowledgements

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